2000

Today in MOVES (presentation to Navy TIMS Conference)

Zyda, Michael

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Today in MOVES

Michael Zyda
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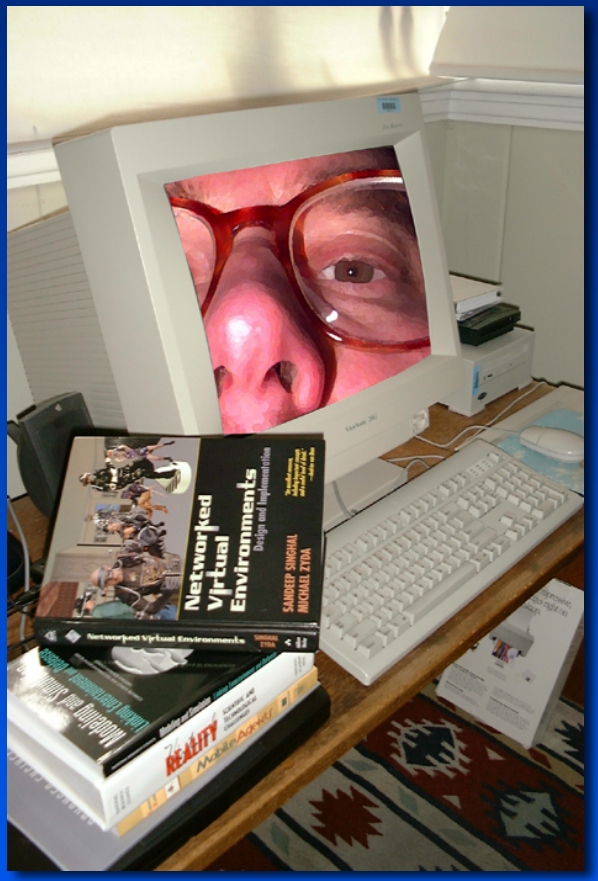
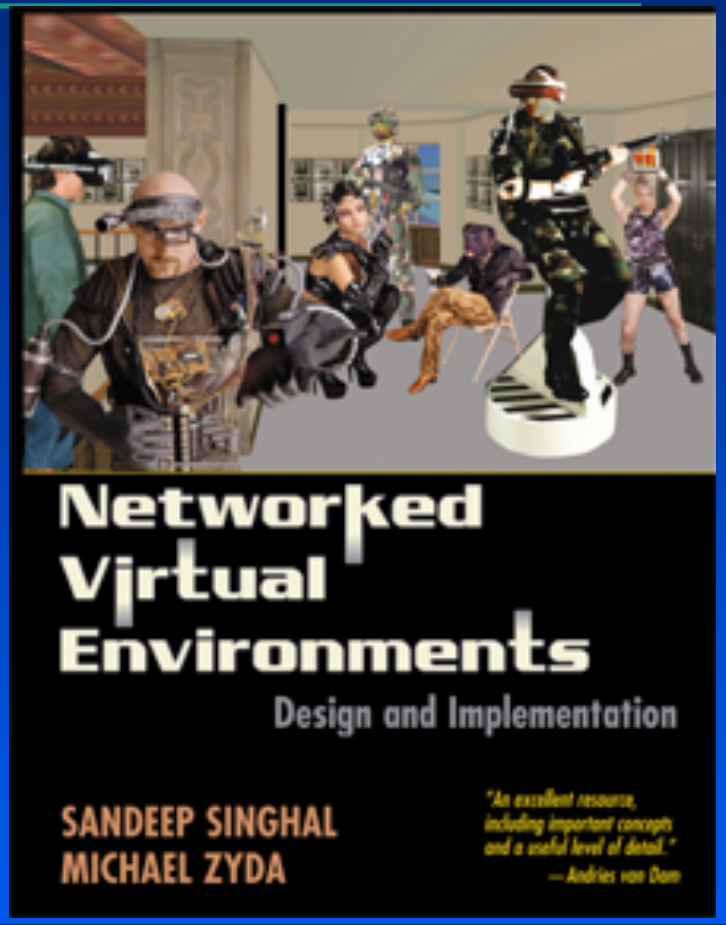
Talk Outline

- Zyda Bio in Book Covers
- MOVES Academic Program
- The NPS MOVES Institute



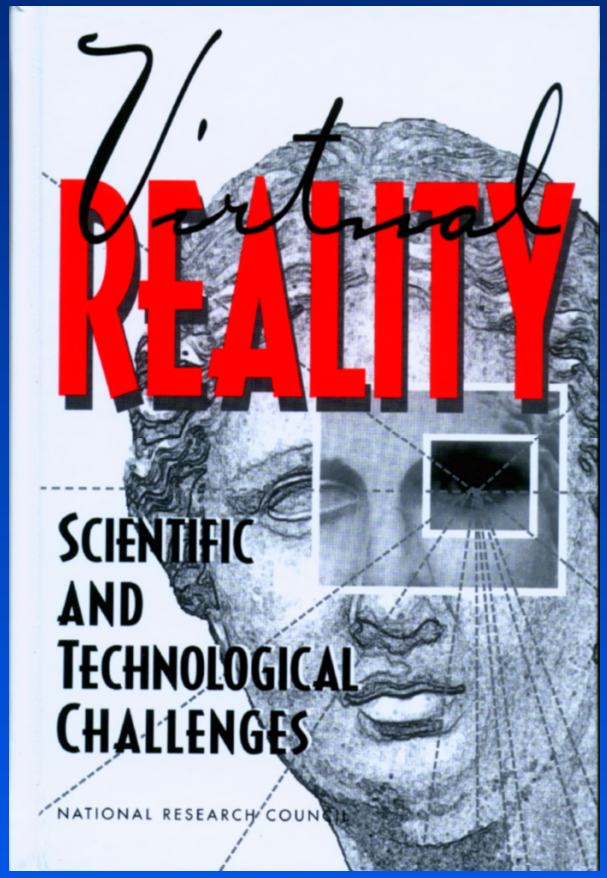
Zyda Bio

Professor Zyda has directed the NPSNET Research Group at the Naval Postgraduate School since its creation in 1986. His research is on software architectures for large-scale, networked virtual environments.

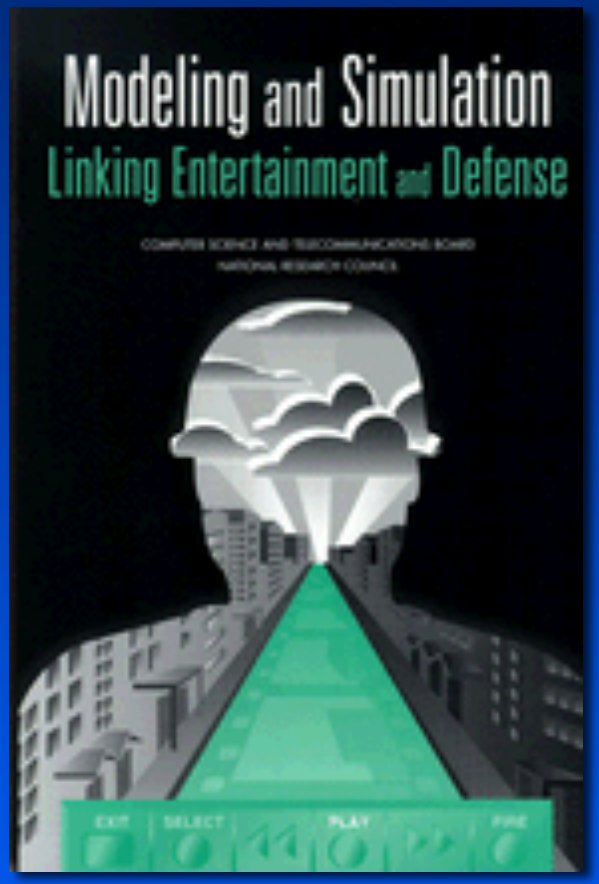


Zyda Bio - NRC 1992 - 1995

Zyda is one of the key authors of the NRC Commission on Behavioral & Social Sciences report "Virtual Reality - Scientific & Technological Challenges"



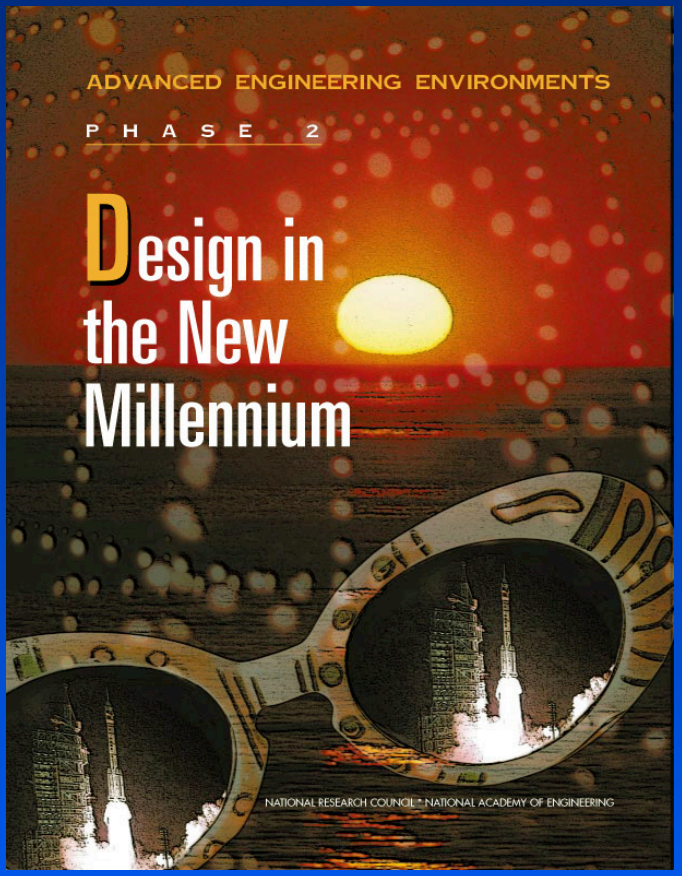
Zyda Bio - NRC 1996 - 1997



Professor Zyda chaired the NRC Computer Science & Telecommunications Board report "Modeling & Simulation - Linking Entertainment & Defense"

Michael Zyda - NRC 1998 - 2000

Professor Zyda is a member of the NRC Aeronautics & Space Engineering Board Committee on Advanced Engineering Environments, which has produced two reports on how NASA should design space systems in the future (2015), using VEs of course!



Zyda Consulting

White House Office of Science and Technology Policy, the Ministry of Industrial Development Sabah Province, Malaysia, Japan Tech Services Corporation, Tokyo, Hitachi Plant Construction & Engineering, Ohtsuka, SimGraphics Engineering, Silicon Graphics International, Geneva, Nihon Silicon Graphics KK, Advanced Telecommunications Inc., TecMagik, SpiritChannel.com, Paramount Digital Entertainment, Celebrity Speakers, International.

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So on with the main talk ...

NPS MOVES Academic Group

The NPS MOVES program is the strongest technical curriculum in modeling, virtual environments and simulation in the world.

- The MOVES degree program is a balanced blend of Computer Science & Operations Research.
- NPS is the ONLY school that has an approved modeling, virtual environments and simulation PhD program.

Scope of the MOVES MS Curriculum

Programming

Object-oriented programming, data structures, artificial intelligence

Systems & Architecture

Computer systems principles, operating systems, distributed operating systems

Computer Graphics

Computer graphics, image synthesis, computer animation, computer graphics using VRML

Mathematical Fundamentals

Multivariable calculus, linear algebra, probability & statistics

Communications & Networks

Network communication in simulation, virtual environment network & software architectures

Virtual Environments

Virtual world & simulation systems, human factors of virtual environments, training in virtual environments

Modeling & Simulation

Stochastic models, system simulation, physically-based modeling, simulation methodology, introduction to joint combat modeling, modeling human & organizational behavior, agent-based autonomous behavior for simulations

Human-Computer Interaction

Interactive computation systems, human performance measurement, human performance evaluation, human factors in system design

MOVES PhD Program - Areas of Study

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- Physically-based modeling for virtual environments
- Networked virtual environments
- Human factors in virtual environments
- Adaptable software agents
- Modeling human and organizational behavior
- Discrete-event systems modeling
- Data and model visualization

MOVES Students

There are 23 MS MOVES officer/graduates since our beginning in March of 1996.

- 11 Navy (6202-P), 9 Army (FA-57), 2 Turkish & 1 Singapore.

There are currently 27 officers in the MOVES MS program.

- 18 Navy, 1 Marine (MOS-9625), 4 Army, & 5 Turkish

There are 6 PhD students currently in MOVES.

The MOVES Institute?

Our work is getting large enough that we have begun discussions on forming an organization we call "The MOVES Institute" (The MOVES Research Center?). In FY00, MOVES was 13% of all NPS reimbursable funding.

- The purpose behind the institute is to provide a political home for researchers & faculty working on MOVES projects.
- Underneath the MOVES Institute will be the MOVES Academic Group, the curriculum that is symbiotic with our funded research efforts.

MOVES Institute - Vision

The vision for the MOVES Institute is to be THE world-class institute for research, application and education in modeling, virtual environments and simulation for the Department of Defense.

The institute carries out basic & applied research, & creates advanced prototypes of defense interest, with the focus on mid-term, long-term, fundamental modeling, virtual environment and simulation problems.

MOVES Institute - Focus

- Networked Virtual Environments
- Computer-Generated Autonomy
- Human-Computer Interaction
- Technologies for Immersion
- Modeling & Simulation
- 3D Visualization
- Defense & Entertainment Collaboration

Research Agenda

Networked Virtual Environments

Networked virtual environments - Scalable integration of interactive three-dimensional graphics, distributed modeling, local-area and wide-area networking, unicast versus multicast routing, integrated multimodal environments, & applications of virtual reality. **High bandwidth networks** - experimentation & utilization of next-generation Internet technologies for large-scale, networked virtual environments, & collaborative M&S development and application. **Wireless** - handheld delivery systems. **Latency-reduction** - techniques for predictive modeling in distributed simulations. **VE architectures for interoperability** - Network software architectures for scalability, composability & dynamic extensibility. **Standards for interoperability**

Computer-Generated Autonomy

Computer-generated virtual environment characters & semi-automated forces - Human & organizational behavior modeling. Agent-based adaptive simulation. Software architectures for computer-generated autonomy.

Individual behaviors - computer-generated characters that accurately portray the actions & responses of individual participants in a simulation. **Adaptability** - computer generated characters that can modify their behavior automatically. **Learning** - computer generated characters that can modify their behavior over time.

Human representations & models - authentic avatars that look, move, & speak like humans. **Story line engines** - content production and simulation prototyping. Technologies for autonomous, real-time story direction and interaction.

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Human-Computer Interaction

Training in the virtual environment - Fidelity requirements for wayfinding in the virtual environment.

Human factors in virtual environments - Multimodal interfaces, task analysis, spatial orientation & navigation, performance evaluation, interaction techniques, interaction devices, virtual ergonomics, cybersickness, usability engineering, training transfer, human perception.

Modeling human and organizational behavior - Integrative architectures for modeling of individuals, including neural networks; rule-based systems, attention & multitasking phenomena, memory & learning, human decision-making, situation awareness, planning, behavior moderators, modeling of behavior of organizational units, modeling of military operations, & modeling of information warfare.

Research Agenda

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Technologies for Immersion

Image generation - real-time, computer graphic generation of complex imagery, HDTV, DVD, next generation delivery systems, novel display technologies, handheld & body-worn devices. **Tracking** - technologies for tracking human participants in virtual environments. **Locomotion** - technologies that allow participants to move through virtual environments. **Full sensory interfaces** - technologies for providing a wide range of sensory stimuli: visual, auditory, olfactory, & haptic. **Novel sound systems** - generation and delivery for both interactive and recorded media. Spatial sound.

Research Agenda

3D Visualization

Data and model visualization - Use of virtual environments for real-world modeling & model exploration of processes; differential, difference, and integral equations; stochastic processes; associated numerical-approximation methods; and inferences from numerical experiments.

World Modeling - Immersive ship & building walkthroughs (damage control, hostage extraction, urban warfare), ocean environment tactical visualization, C4I/IW information visualization, game-engine utilization.

Defense & Entertainment Collaboration

SimNavy, Army Game Project, SimMedicalCenter, SimSecurity, D.Labs Initiative

Modeling & Simulation

Physically-based modeling - Computational modeling of physical relationships and processes for real-time execution, including rigid and flexible body dynamics, collisions, fluid dynamics, environmental effects on motion, feedback, tracking, representations of the world, and related numerical methods. **Dynamic & state space modeling for IW/IO** - High-resolution combat models. High-level aggregate models. Network centric warfare. Modeling of plan-based actions for intelligent agents in simulations. Theater, tactical and campaign level modeling. Decision making in test & evaluation. **Advanced Engineering Environments.**

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Networked Virtual Environments

Extensible 3D (X3D) Graphics and Virtual Reality Transfer Protocol (vrtp)

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3D Graphics on the Web: VRML, X3D

- VRML in XML, Web3D Consortium

Networking 3D with DIS-Java-VRML

- Free Java implementation of DIS protocol
- Can be used to animate VRML/X3D scenes
- Multicast networking capable
- Portable across all platforms.

vrtp
- what does the desktop look like?

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client

- looking at someone else's world

server

- showing others your world

peer

- scalable behavior interactions

"everything just works"

vrtp
- virtual reality transfer protocol

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HTML **http**

VRML / X3D **vrtp**

Networked Virtual Environments - A Vision

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Eventually, there will exist a persistent virtual environment simultaneously shared by millions.

There can never be a global reboot.

All modifications must happen on the fly.

The development of participant programs (live & autonomous characters) for that VE must be as simple as writing a web page is today ...

Requirements for that Vision - Network Software Architecture

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Extensible/Composable/Interoperable

- Cross-platform, component frameworks
- Dynamic Behavior Protocols

Ability to Suspend/Resume State

- Persistent Universe

Large-Scale/Infinite Number of Players

- Area of Interest Management

Standards for Interoperability

We must be designing standards for interoperability that are as simple to use as writing a web page …

- So once we have done all the net-VE work on the previous slides, we can then think about standardization …

For more information on Net-VEs ...

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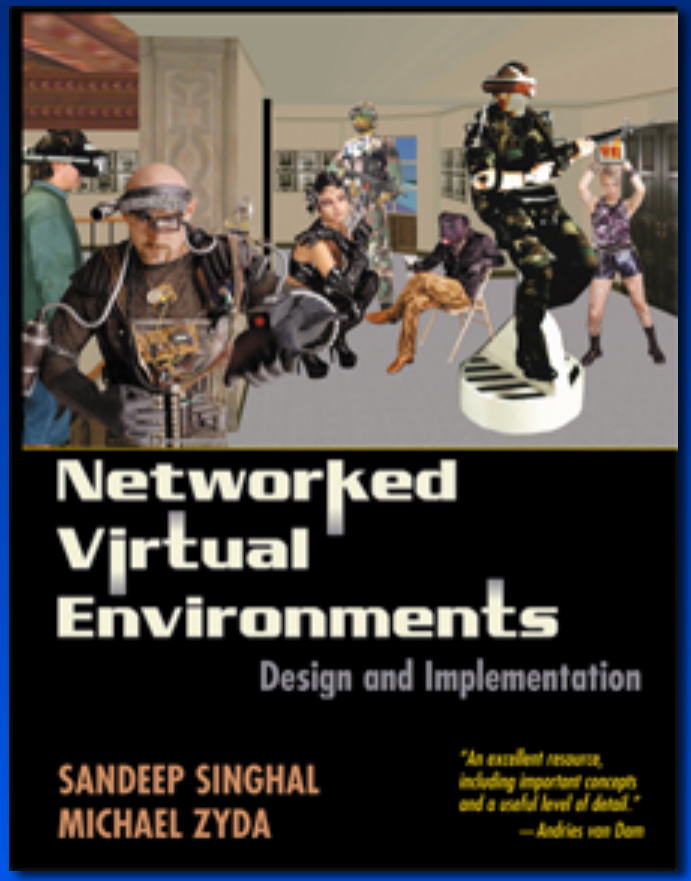
Sandeep Singhal & Michael Zyda

"Networked Virtual Environments - Design and Implementation,"

ACM Press Books, SIGGRAPH Series, July 1999,

ISBN 0-201-32557-8.



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Computer-Generated Autonomy

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Computer-Generated Characters

- We want computer-characters in our net-VEs with whom we can interact in an intelligent fashion.
- We want autonomous behaviors for those characters.
- We want characters that can come in over the network and play with us, educate us, train us, characters that can learn and help guide the VE's story.

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Computer-Generated Characters

We need software architectures that can provide:

- Adaptability - modify behavior automatically
- Learning - modify behavior over time, reinforcement learning.
- Agent-based - to allow for emergent behaviors.
- Behavior & Story Modeling
- High quality avatars

Networked Agent Architecture

- Develop an NPS-owned agent-based simulation engine.
- Develop an architecture to allow the engine to work in a distributed fashion.
- Develop tools for specifying the interiors & the interactions of the agents.

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RELATE - NPS Agent Architecture

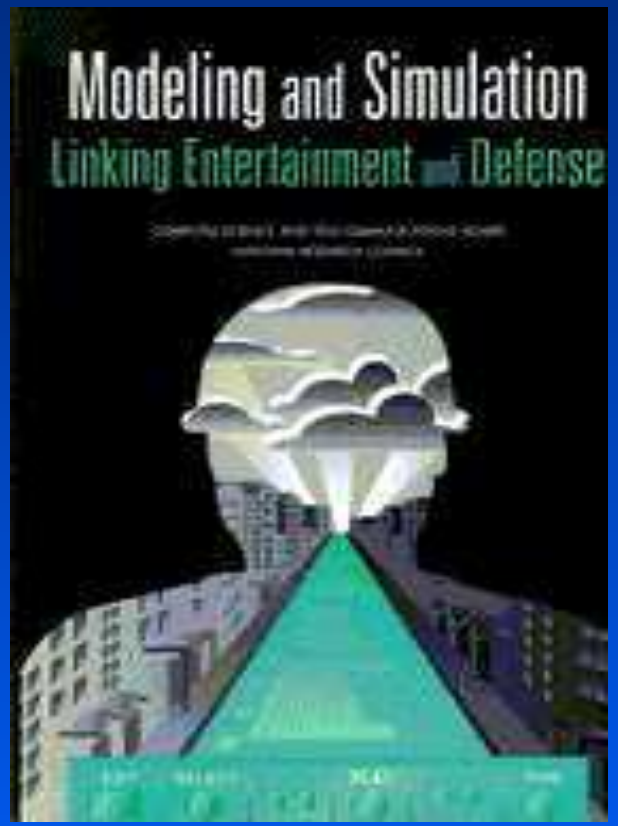
Modeling Human and Organizational Behavior with a Relation-Centric Multi-Agent System Design Paradigm

RELATE

Storyline Engine

"… skilled storytelling techniques help participants in a virtual environment sense that they are in a real environment and behave accordingly."

- *Develop autonomous agent technology to carry out high level behavior of characters in a networked virtual environment*
- *Develop technology to guide those behaviors within the parameters of a given story line.*



Storyline Engine - Initial Design Concept

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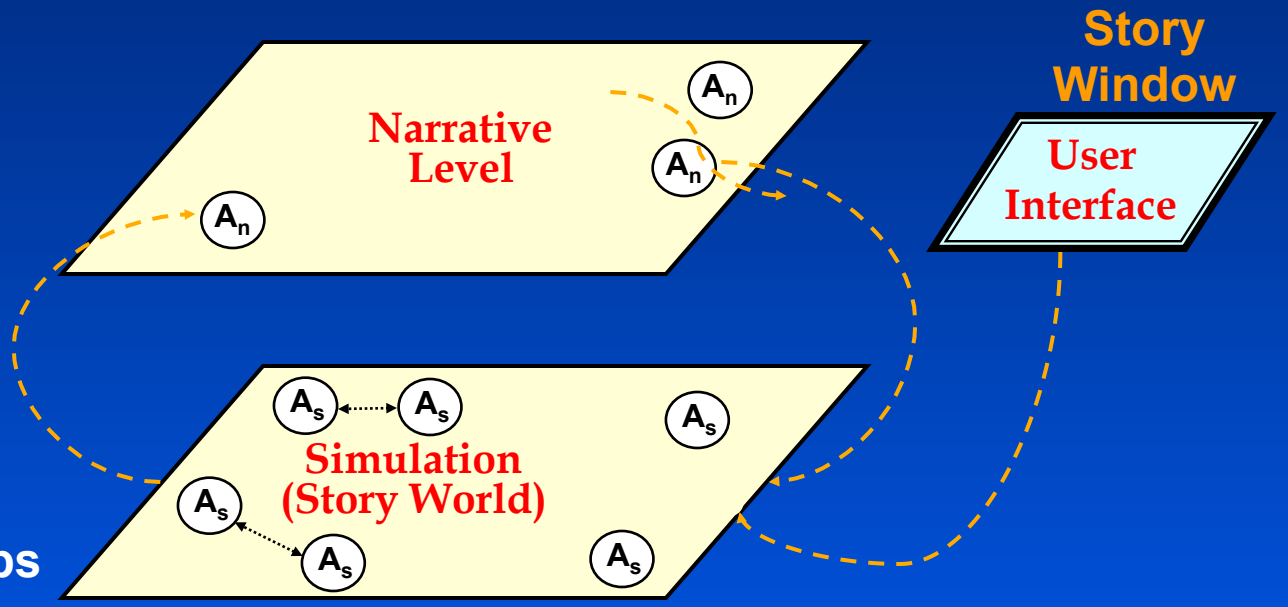
Narrative RELATE Architecture

RELATE Architecture
- Relationships
- Roles
- Goals
- Rules



Design Challenges

- *Narrative Architecture*
  - Crafting and Feedback Actions
  - What needs to be fed to the Narrative Agents
- *Agent Autonomy*
  - Autonomy vs. Story Control
- *Objective Function*
  - Dramatic Intensity
  - Event Sequencing

Where to from here?

- Build a simulated world based upon a simple story
- Develop Narrative Architecture
- Demonstrate proof of concept
- Integrate Narrative Architecture into "Recruits"
- Multiple Narrative Levels and Story Windows

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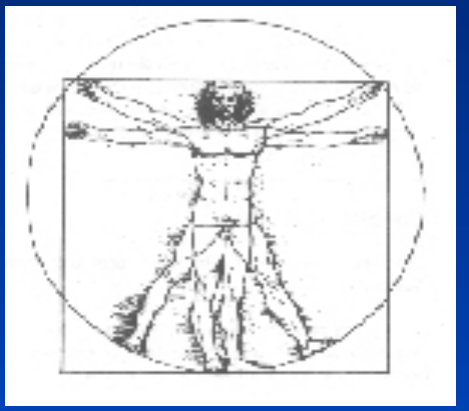
Human-Computer Interaction

The HCI Track in MOVES



Quantitative Skills

- Probability
- Statistics

Human Performance

- Human Performance Measurement
- Human Factors in System Design
- Interactive Computation Systems
- Human Performance Evaluation

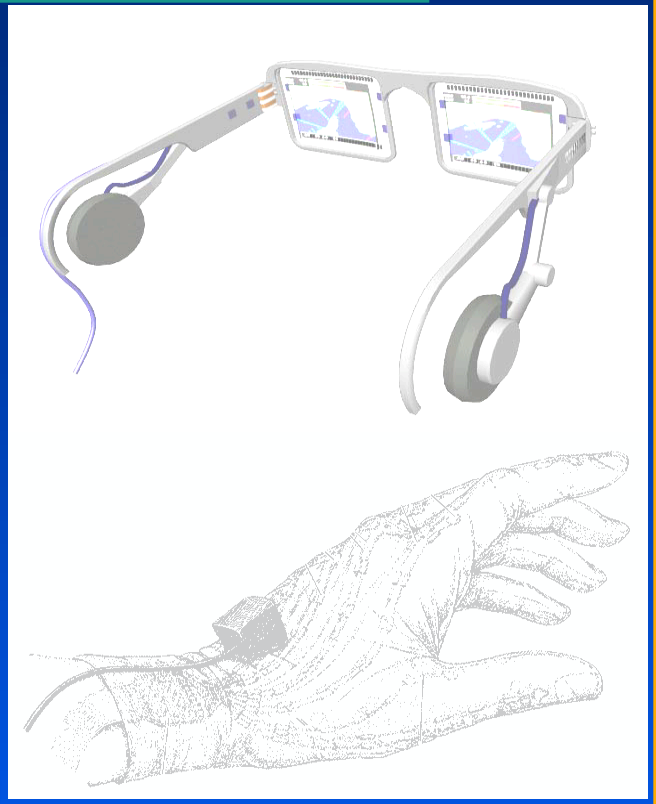
New Course Development

Human Factors of Virtual Environments

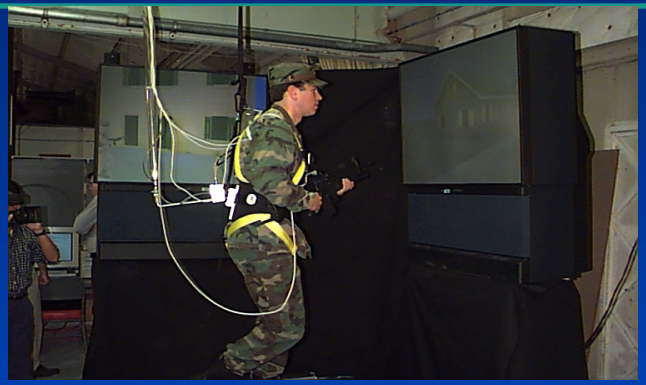
- Interaction techniques
- Cybersickness / Presence
- Navigation and Wayfinding

Training in Virtual Environments

- Transfer of training
- Learning curves
- Adaptive behavior / Feedback mechanisms



Thesis Research



Locomotion Techniques

Land Reconnaissance

Helicopter Navigation

Land Navigation

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Technologies for Immersion

Technologies for Immersion

Image generation - real-time, graphics computers capable of generating complex visual images, novel display devices.

- 1,000 Mhz to 300 Ghz clock rates.
- 300M to 4.8B textured polygon/second.
- GBs of on-board memory.
- Handheld, wireless, sunglasses-like HMDS (game machine platforms!) …
- This is the hardware that is coming …

Trends - Game Machine Platforms

Playstation 2 --> Rasterize 75M polygons/second and transform 66M polygons/second.

Playstation 3 --> 1,000 times faster than that in five years? 66B polygons/second?

Playstation 2 & Descendents

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Platform	Polygons/Second	Display Resolution	Availability	Notes
Playstation 2	66M	640 x 480	Mar-00	Emotion Engine & Graphics Synthesizer
				Emotion Engine is the CPU & has 13M transistors
				0.18 micron process.
				$1.1B fab!
				$472M for Emotion Engine fab
				$660M for the Graphics Syn. Fab.
Creative Workstation	10 x PS-2	1920 x 1080/60p	2000	Parallel faster versions
Phase 1	660M?	(progressive)		of Emotion Engine & Graphics Synthesizer
				in Playstation 2.
Creative Workstation	100 x PS-2	1920 x 1080/60p	2002	Emotion Engine 2
Phase 2	6.6B?	24 to 75 fps		Graphics Synthesizer 2
				CPU 40M transistors
				0.13 micron process
				Will be able to handle movie production.
Creative Workstation	1000 x PS-2	4000 x 2000	2005/6	Emotion Engine 3
Phase 3	66B?	24 to 120 fps		Graphics Synthesizer 3
				Radically different architecture
				Server for theaters?
Playstation 3	66B?		2005/6	Based on Phase 3
Reference				
Yoshiko Hara, "Microprocessor Forum: Sony to us Playstation 2 technology for workstation line,"				
	7 October 1999, EE Times			

Visual Reality

Visual reality is 80M polygons/picture [Catmull, 1984] & [NRC 95, pg. 252].

- 80M polygons/picture at 60 pictures/second (fps) is 4.8B polygons/second.
- We are talking about machines that can visually display computer images indistinguishable from reality.

What we are doing with respect to technologies for immersion?

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Evaluating & utilizing commercial game engines.

X-Box & other game consoles

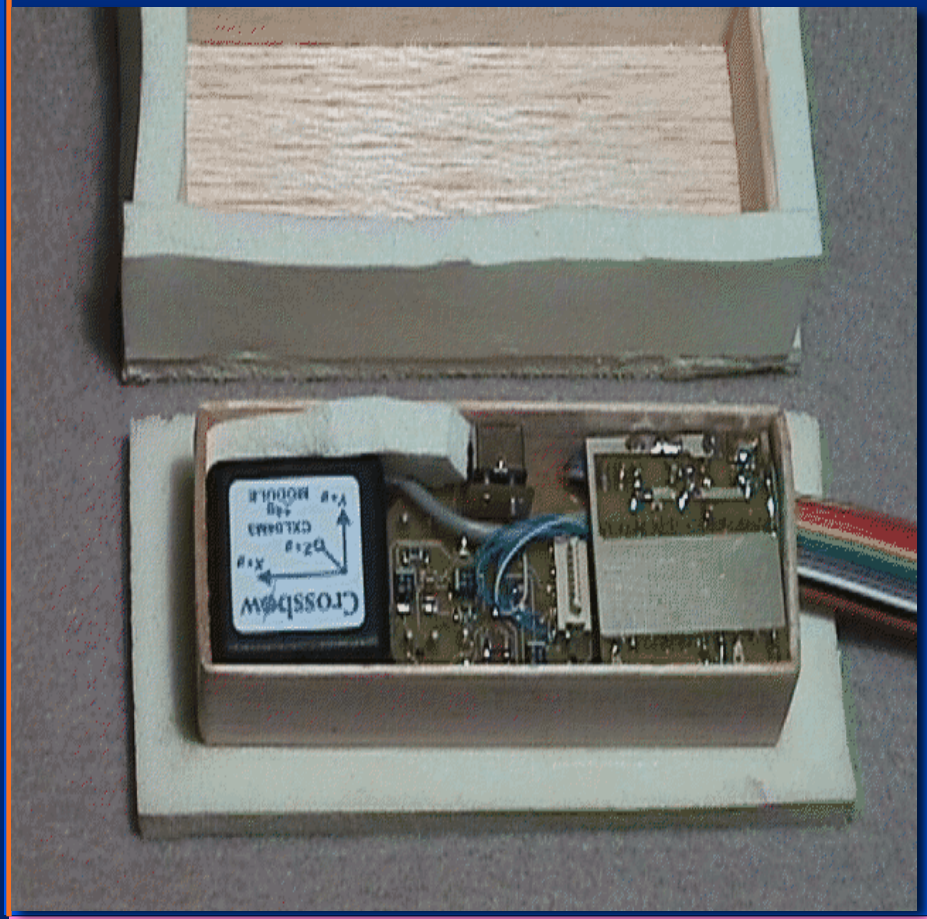
- Very hard to make this happen but we are looking at consoles for the ArmyGame Project.

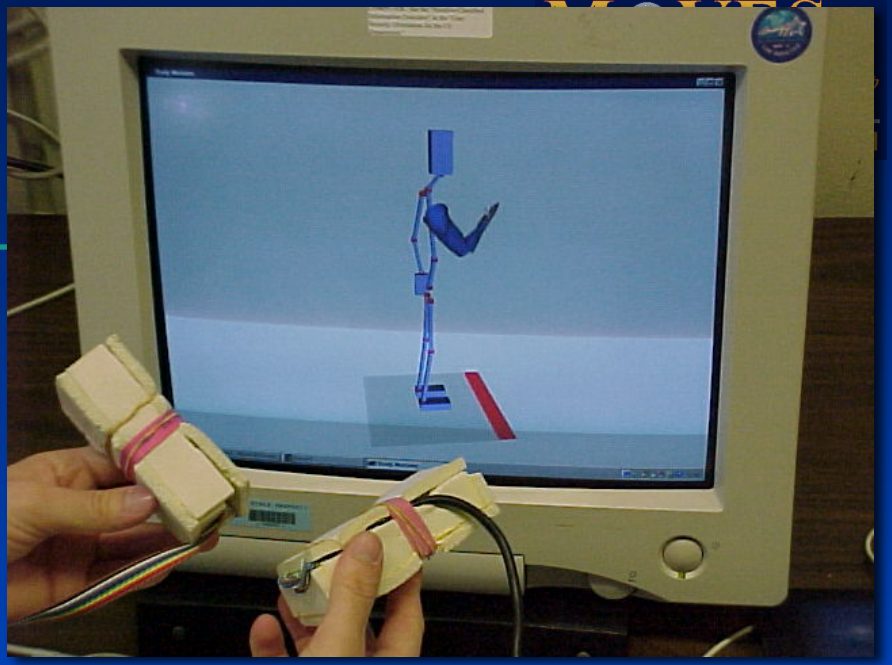
Technologies for Immersion

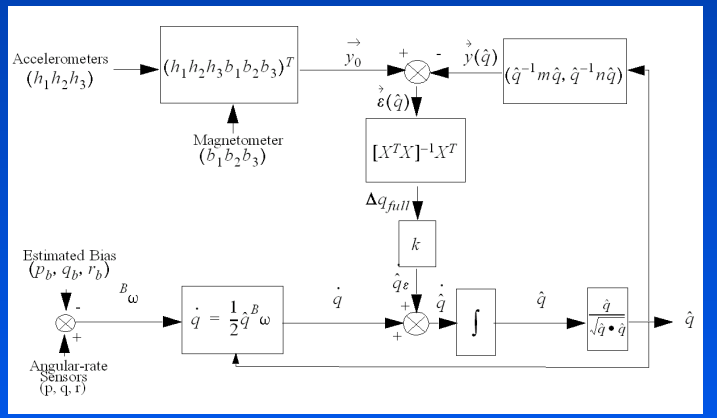
Tracking - technologies for keeping track of human participants in virtual environments.

- We still don't have the trackers we desire!

NPS MOVES
- Inertial Tracker







Technologies for Immersion

Full sensory interfaces

- Technologies for providing a wide range of sensory stimuli: visual, auditory, olfactory, & haptic.

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Defense & Entertainment Collaboration

Projects in Defense/Entertainment Collaboratation

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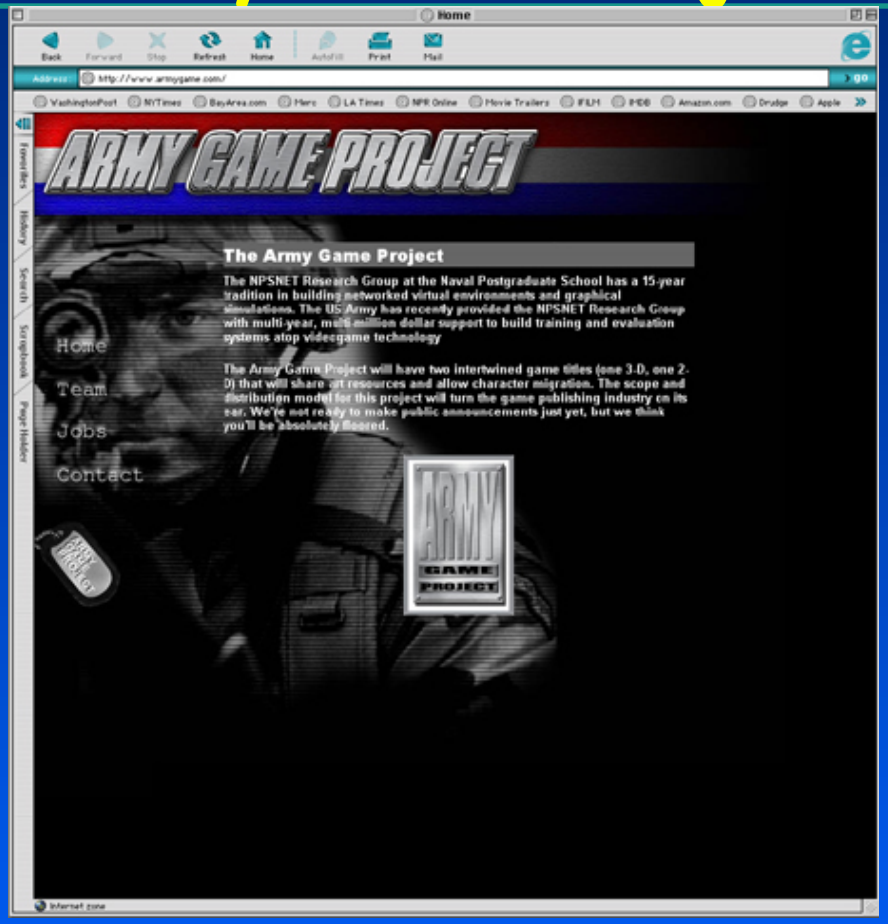
- *Army Game Project*
- *SimSecurity*
- *SimMedicalCenter*
- *D.Labs Concept*

Army Game Project



We've been funded by the US Army to build videogame software for team training.

Funding from Assistant Secretary of the Army for Manpower & Reserve Affairs, $12M over 5 years.

http://www.ArmyGame.com

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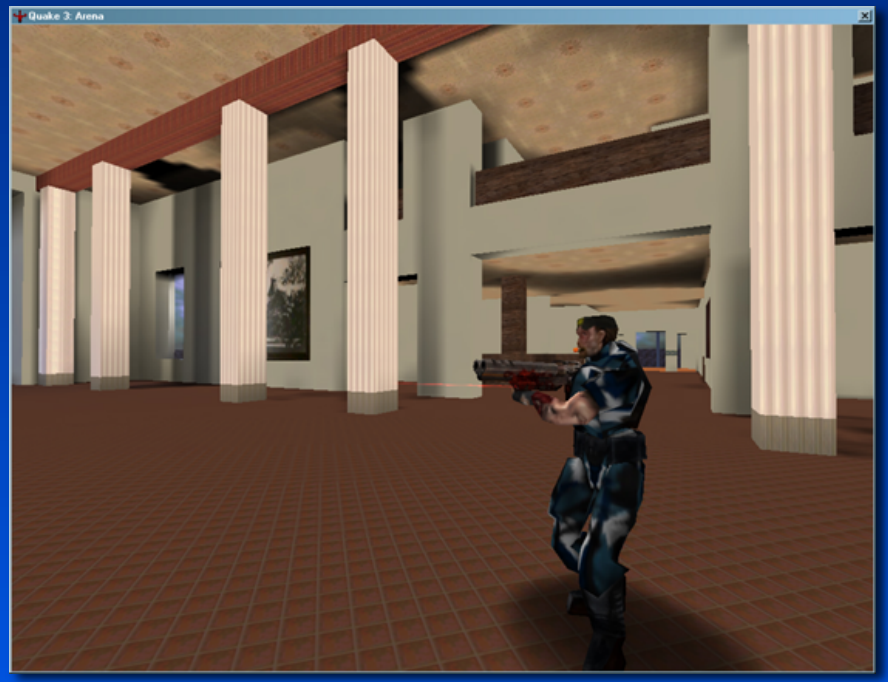
Army Game Project

We are building two intertwined game titles

- One 3D - similar to Unreal/ HalfLife,
- One 2D - similar to TheSims
- The games will share art resources and allow character migration.
- Distribution - free on the Internet & in game boxes.



Army Game Project - What is the research?

We are looking into how videogames can be instrumented to be able to determine:

- Aptitude, leadership abilities & psychological profile.
- We are hoping to expand our work to include a separately funded system (using common architectures) for allowing "kids at risk" to also be able to explore potential career paths ...

SimSecurity

SimSecurity

- With Professor Cynthia Irvine & CISR
- Funded by DMSA & N6 - $1.5M for 24 months. Funding here now.
- A game-like simulation to explore threats to computer networks from the perspectives of the various players (IT manager, hacker, …)
- Benign, Normal & Hostile environments settable.

SimMedicalCenter

SimMedicalCenter

- Funding from the USAF via USA TRAC Monterey, $2.3M over 24 months. Starter funding here now.
- Goal is to develop a game-like simulation of the operation of a DoD medical center.
- Again, we will provide a Benign, Normal & Hostile environment settable by the player.

D.Labs Concept

Distance Learning through game-like simulations is becoming a big component of our work so we have developed a concept we call D.Labs for our "MOVES Institute".

- We have the prospect of providing a platform for school-wide distance learning using our expertise in developing networked simulation games.
- We are exploring D.Labs with NPS IDEA.


Any questions?
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VR